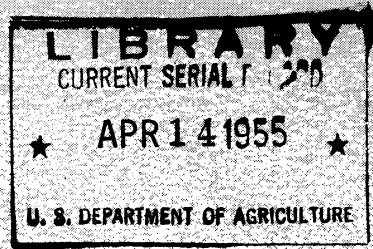


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Farm Methods of COOLING MILK



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UNITED STATES DEPARTMENT OF AGRICULTURE.

MILK that is not cooled promptly deteriorates rapidly and usually brings a lower price than milk that is properly cooled. Every dairyman who produces and delivers high-quality milk encourages increased consumption of dairy products.

The greater part of the country's milk supply is produced on farms where either mechanical refrigeration or natural ice is available. Even where neither of these is at hand, the farmer can do a reasonably good job of cooling milk through proper use of the available water supply.

It is just as important to cool cream as it is to cool milk, and the same equipment and methods are used.

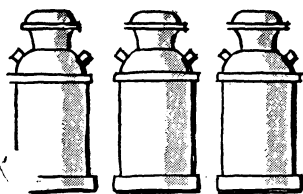
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X Farm Methods of COOLING MILK



By Fred M. Grant, dairy manufacturing technologist, Dairy Husbandry Research Branch, Agricultural Research Service

The dairy farmer's income depends largely on his ability to sell all the milk he produces at the best possible price. Every dairyman who produces and delivers high-quality milk to the processor helps raise the average quality of all the milk the processor receives. If the processor receives high-quality milk, he can supply high-quality milk and dairy products to the consumer. This should encourage increased consumption of milk and dairy products, and should result in a greater return to the farmer.

Milk that is not cooled promptly and properly on the farm and kept cold until it is delivered to the processor deteriorates rapidly. Almost any farmer can provide some means for cooling milk and keeping it cold. He can use mechanical refrigeration, ice, or well water. Whatever facilities the farmer has available and whatever method he uses, he should use to the fullest extent necessary to do the job properly.

Electric power, which is now available on more than 84 percent of the farms in the United States, makes possible the use of mechanical refrigeration for cooling and storing milk. Gasoline engine power also makes mechanical refrigeration possible. In the Northern States, farmers can store and use natural ice. Where neither mechanical refrigeration nor ice can be provided, the farmer must depend on water from a well or spring. Proper use of this water in the surface cooler and the wet storage tank will cool the milk and hold it at a temperature within 2 or 3 degrees of the temperature of the water.

COLD RETARDS BACTERIAL GROWTH

Milk usually contains very few bacteria as it leaves the udder of a healthy cow. But no matter how carefully the milk is handled after it is drawn, additional bacteria may get into it from the air and from dust and dirt falling from the cow's udder and flanks during milking, and from utensils that have not been cleaned and sanitized properly.

Bacteria grow and multiply rapidly in warm milk and, although they may be harmless, they soon cause souring or other undesirable changes. Milk has a temperature of about 90° F. as it leaves the udder. Bacteria grow rapidly at this temperature, but if the milk is cooled to below 50° the bacteria increase at a much slower rate. At 40° and below, the rate of increase is still slower.

Experiments at the Michigan Agricultural Experiment Station showed that freshly drawn milk contains a germicidal factor which helps to retard bacterial growth for a short time after milking. These experiments also showed that if the milk is cooled promptly after

it is drawn, the germicidal factor is preserved and will aid in retarding bacterial growth if the milk later becomes warm.

Although prompt cooling is necessary to check bacterial growth in milk, storage at a low temperature to keep the milk cold is also necessary. Many experiments have shown the effect of different storage temperatures on the rate of bacterial growth. Table 1 shows the comparative effects of storage at 40°, 50°, and 60° F. on the rate of bacterial growth in milk having an initial count of 4,295 bacteria per milliliter. These results clearly indicate the importance of storing milk below 50°.

TABLE 1.—*Rate of bacterial growth at different storage temperatures*

Storage time (hours)	Average number of bacteria per milliliter of milk, when stored at—		
	40° F.	50° F.	60° F.
0.....	4, 295	4, 295	4, 295
24.....	4, 138	13, 961	1, 587, 333
48.....	4, 566	127, 727	33, 011, 111
72.....	8, 247	5, 725, 277	326, 500, 000
96.....	19, 693	39, 490, 625	962, 785, 714

Although it is of the utmost importance to cool milk promptly and keep it cold to preserve its original quality and prevent an excessive increase in the number of bacteria, cooling is not a substitute for cleanliness in the production of high-quality milk. For further information on producing high-quality milk, see Farmers' Bulletin 2017, Clean Milk Production.

COOLING AND STORAGE FACILITIES

Proper cooling and storage of milk on the farm requires facilities which will cool the milk promptly to 50° F. or below, and then hold it at that temperature until it is delivered. The lower the temperature (below 50° but above freezing), the better the milk will keep.

Use of mechanical refrigeration has become widespread with the rapid increase in the number of farms that have electric service available. Mechanical-refrigeration equipment can be purchased as an integral part of the cooling or storage unit, or it can be purchased separately for use with a unit already on the farm.

The surface cooler is used to cool the fresh warm milk as quickly as possible before it is placed in cold storage. Most surface coolers for farm use consist of two separated, parallel, corrugated surfaces. The two surfaces may be two sheets of metal or a series of parallel tubes. From a receiving tank at the top, the milk flows downward over the outside of the surfaces and is cooled by water or some other cooling medium circulating between the two surfaces or through the tubes.

Wet storage is probably the most common method of keeping milk cold during storage. A wet-storage unit may consist of a tank, a box, or a cabinet, in which cold water is used as the cooling medium. In a tank, the cans of milk are immersed to the neck level in cold water.

In a box or cabinet, the cold water is sprayed over the shoulders of the cans. Wet-storage units are also used quite commonly for cooling freshly drawn milk as well as for storing it at a low temperature.

Dry storage is used for storing precooled milk in bottles as well as in cans. Dry-storage space may be a small box or cabinet, or a comparatively large room called a walk-in box. All must be well insulated. The cooling medium is air, which may be cooled by ice in bunkers or by some form of mechanical refrigeration.

The bulk-holding system is the newest method of cooling milk on the farm and keeping it cold. In the bulk-holding system, the fresh warm milk goes directly into a mechanically refrigerated storage tank. Here it is cooled quickly to the desired temperature and held at that temperature until time for delivery to the processor. The milk may be drawn from the tank into milk cans for delivery in the usual way, but, preferably, it is pumped from the tank into a milk tank-truck for delivery to the processing plant.

Always consult the local milk inspector or health authority before installing any type of milk-cooling equipment.

THE SURFACE COOLER

The modern farm surface cooler usually is the single-panel type, made either of two corrugated metal sheets or of a continuous bank of tubes which form two corrugated surfaces. All the surfaces that come in contact with the milk are made of corrosion-resistant metal, such as stainless steel or tin-coated copper. The cooling surfaces are in one or more sections. A common arrangement is to have the top section connected with the water supply and the bottom section connected with a source of mechanically cooled refrigerant, such as cooled water, cold brine, a nontoxic refrigerant, methyl chloride, or ammonia (fig. 1). A nontoxic refrigerant is preferable to either methyl chloride or ammonia.

The size of surface cooler needed on the farm will vary with the amount of milk to be cooled, the rate of milking, and the type of refrigerant. The manufacturer or dealer who supplies the cooler can advise on the size needed for any farm.

Surface coolers provide the most efficient way of using the available refrigerant. If the surface cooler is managed properly, so that a continuous thin film of milk flows over the surfaces of the cooler, the milk will be cooled to within 2 or 3 degrees of the temperature of the refrigerant in the time it takes for the milk to flow from the top of the cooler to the bottom. Control of the flow of milk is especially important if the refrigerant is relatively ineffective, such as well water. Use of a surface cooler also saves refrigeration expense and shortens the time required for cooling. Rapid cooling is advantageous under all circumstances, because it is important to reduce the temperature of the milk quickly to the point where growth of bacteria is retarded or stopped.

Experiments by the Department of Agriculture have shown that precooling the fresh warm milk over a surface cooler, even if the refrigerant is only well water, will greatly shorten the time required to lower the temperature of the milk to 50° F. in either wet or dry storage. For example, figure 2 shows that the temperature of the milk



FIGURE 1.—Surface cooler, with top section cooled with water and bottom section cooled with refrigerant.

will be lowered to 50° in approximately 20 minutes if the milk is pre-cooled over a surface cooler with water at 55° and then placed in a wet-storage tank in which the initial temperature of the water is 37° , whereas if the fresh milk is put directly into the same wet-storage tank without being pre-cooled it will take about an hour for it to reach 50° . Comparable results will be obtained if dry storage is used instead of a wet-storage tank.

Precooling the warm milk over a surface cooler not only gives added protection to the milk but actually saves refrigeration and thereby reduces the cost of producing the milk. In addition, it aerates the milk, which is a further beneficial effect. Experiments some years ago by the Department of Agriculture showed that prompt aeration of warm milk removes silage flavor and odor when the milk is only slightly tainted and reduces the degree of flavor and odor when the

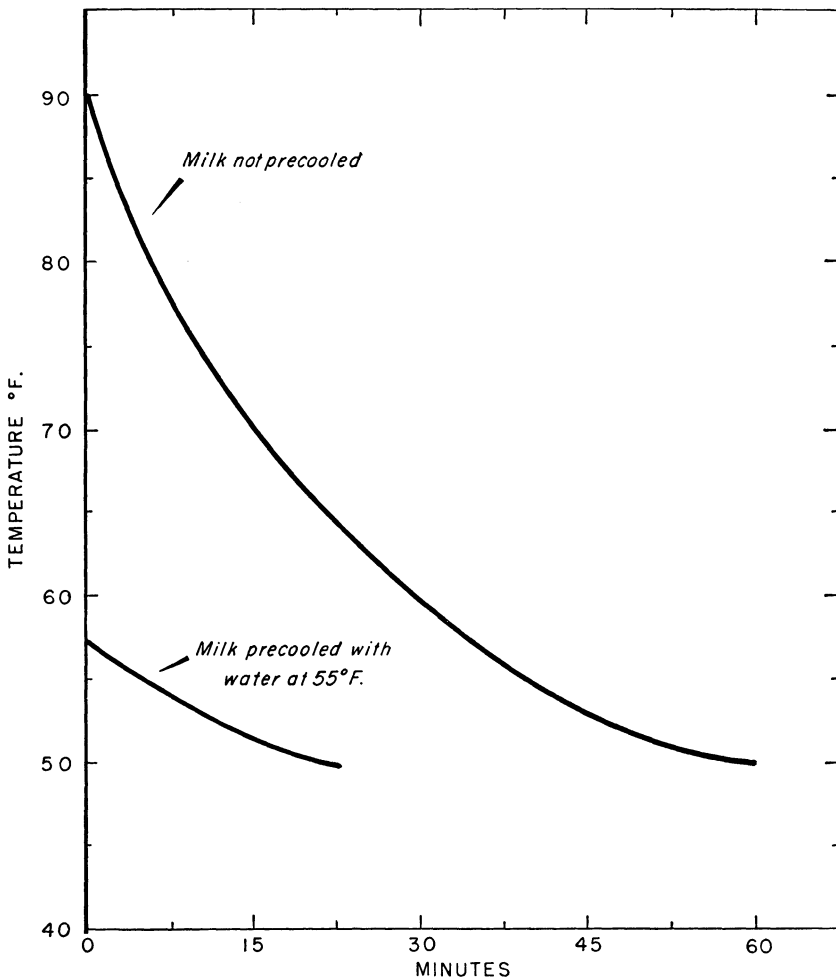


FIGURE 2.—Comparative time required to cool milk to 50° F. in tank water having an initial temperature of 37°, when the fresh warm milk has not been precooled and when it has been precooled over a surface cooler with water at 55°.

milk has a pronounced taint. Similar results were obtained with other objectionable flavors and odors. To be effective, the milk must be precooled in a room where the air is clean, fresh, and free from dust and odors.

The milk from each cow should be precooled immediately after it is drawn, without waiting for all cows to be milked. Then, as soon as a can is filled with precooled milk, it should be put in cold storage.

Each piece of dairy equipment is a possible source of bacterial contamination of the milk. The surface cooler is no exception. It is essential, therefore, to keep the cooler clean so that the bacterial count of the milk will be held down to an acceptably low number. To make cleaning easy, the cooler should be set out from the walls or away from cabinets or other equipment so that all sides can be reached easily.

Otherwise, it is difficult if not impossible to clean the obstructed sides thoroughly. (See fig. 3.)

COLD STORAGE OF MILK

After the milk has been precooled, it must be stored at a low temperature until it is picked up at the farm for delivery to the processor. If the milk is precooled over a surface cooler, with well water as the refrigerant, it usually will need further cooling during storage. Cold storage may be wet storage, dry storage, or bulk storage.

Wet Storage

Storing milk in containers set in water is about the oldest form of cold storage still in use. The early settlers of our country put their containers of milk in a well or spring, and many farmers still store their cans of milk in a tank or pool in a springhouse.

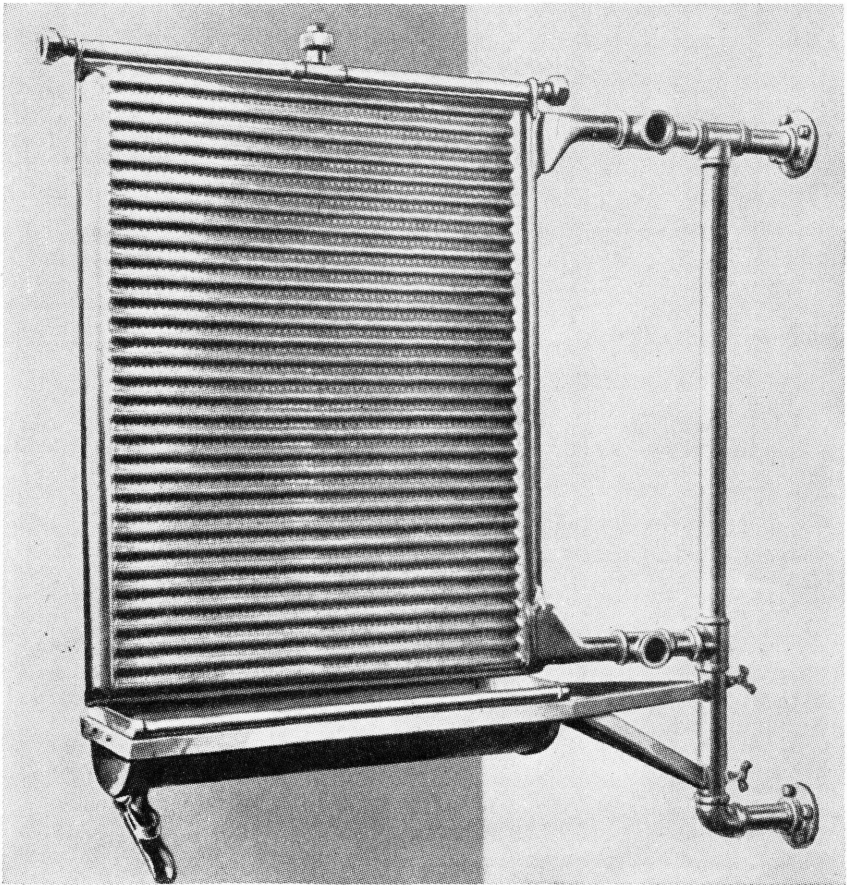


FIGURE 3.—A surface cooler arranged for wall mounting, which permits easy cleaning of each side. The cooler illustrated is in one section only and therefore only one cooling medium can be used at a time.

The immersion type of wet-storage tank is one in which the cans of milk are placed in water up to their necks. The tanks are constructed of various materials. Those purchased from dairy supply houses are portable, usually are made of sheet metal, and are well insulated. The inner lining is made of corrosion-resistant metal or is treated to prevent rust and corrosion. Homemade tanks sometimes are made of wood. A common type is made of concrete and usually is built as a part of the milkhouse (fig. 4). Plans for concrete storage tanks usually can be obtained from your county agent or the State college. Most companies that sell cement are also able to furnish plans for concrete milk tanks.

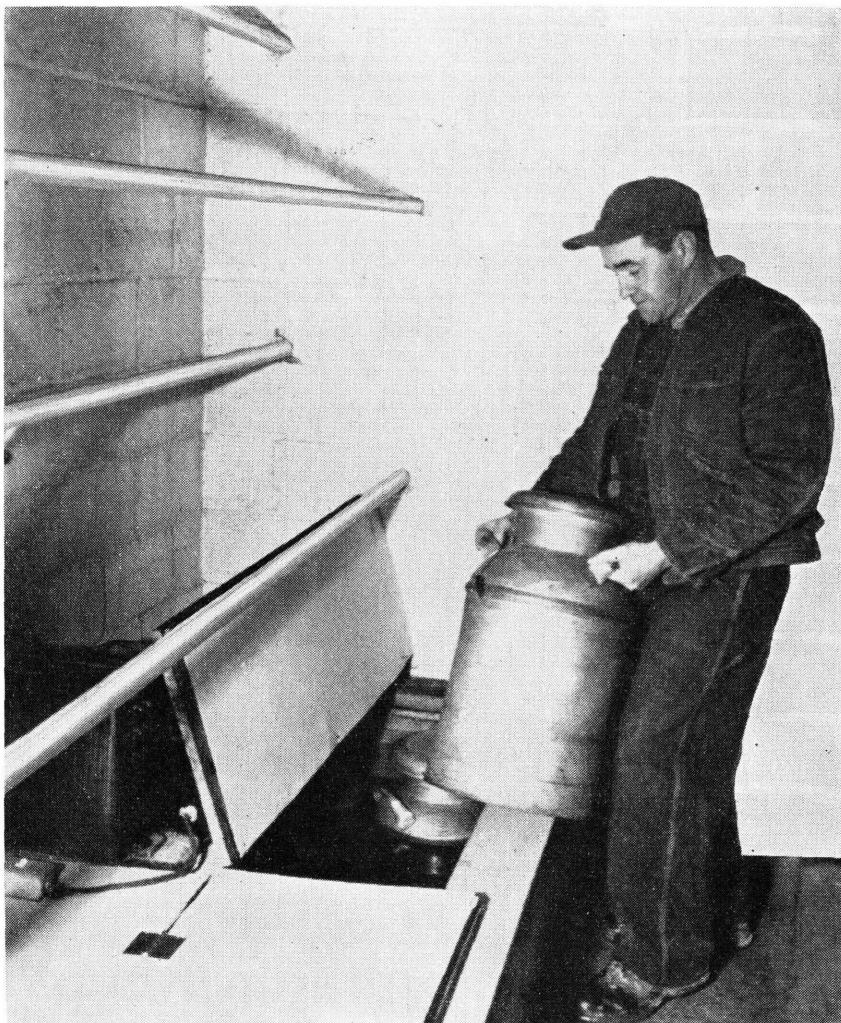


FIGURE 4.—A concrete immersion-type wet-storage tank built into the milkhouse. Note the compressor, which in this case is on top of the tank, and the rack for clean cans over the tank.

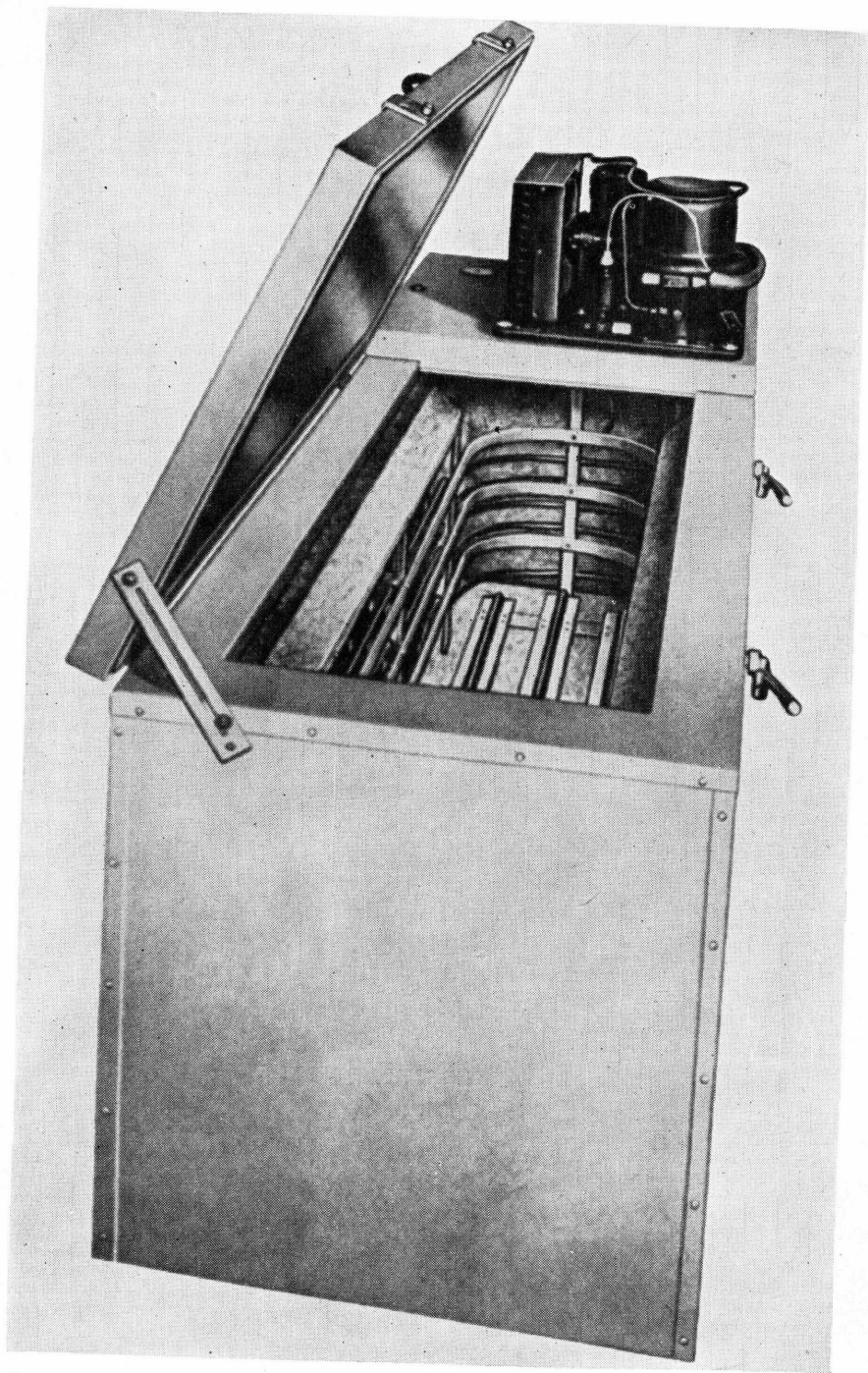


FIGURE 5.—A mechanically cooled wet-storage tank of the immersion type, sold as a unit, showing the cooling coils and guards.

An immersion-type tank should be constructed so that it can be drained completely and cleaned easily. It should have a slat rack near the bottom to hold the cans. This will keep the cans off the bottom and allow the water to circulate under the cans.

In the modern immersion-type tank the water is almost always cooled by mechanical refrigeration. The refrigerant is circulated along the sides of the tank through metal coils submerged in the water (fig. 5). The heat from the milk is absorbed by the water, and from the water by the refrigerant in the coils. When an ice bank is allowed to develop around the coils during periods of light loads, extra refrigeration will be available for peak loads.

If mechanical refrigeration is not available, ice may be used to cool the water in an immersion-type tank. The ice should be put in the tank long enough before milking time to be sure the water is cold when the cans of warm milk are put in. Enough ice must be used to cool the milk to 50° F. or below and hold it at that temperature. The amount to use depends on the amount and initial temperature of the water as compared with the amount and initial temperature of the milk. Generally speaking, the greater the amount and the colder the water that is available per unit of milk, the more effective is the cooling. For example, under average summer conditions, 30 gallons of water at an initial temperature of 37° will cool a 10-gallon can of milk from an initial temperature of 85° to about 50°. Twice as much water (60 gallons) at the same temperature will cool the same milk to 45°.

If neither mechanical refrigeration nor ice is available for the immersion-type tank, the coldest water available should be used.

An arrangement for cooling milk with well water, with or without ice, is shown in figure 6. With this arrangement, water may be pumped directly from the well to the surface cooler and to the wet-storage tank, or it may be drawn from the supply tank. Water from the supply tank should be used only during cold weather when it would be colder than water pumped directly from the well. The inlet to

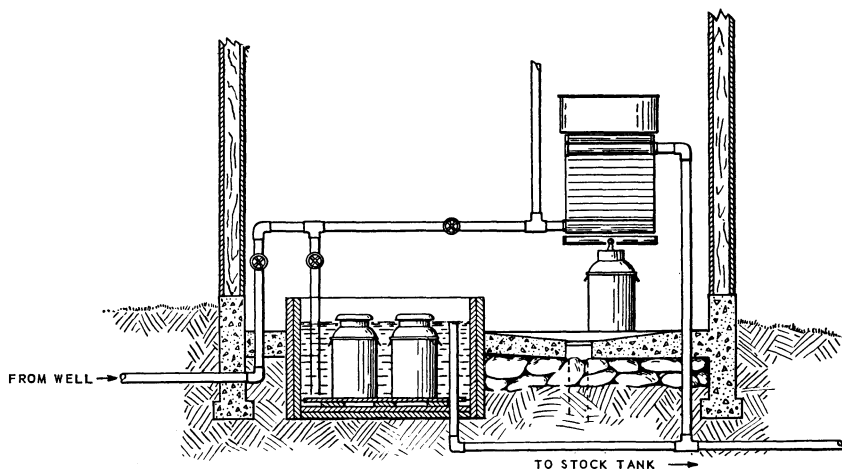


FIGURE 6.—A method of using the farm water supply to cool milk.

the wet-storage tank should be at the bottom of the tank and the outlet near the top, so the water will flow around the cans, taking the heat from the milk, and then out to the stock tank from the overflow near the top.

Agitation of the water in the tank is essential for cooling the milk in the shortest time. Various mechanical methods of agitation are satisfactory if power is available and the equipment is properly constructed. In one method, the water is propelled through a tube from near the bottom of the tank to the surface of the tank water, and is forced along the sides of the tank. This gives double circulation, that is, from the bottom to the top of the tank and lengthwise. In another method, the cold water is pumped from the bottom of the tank through perforated pipes arranged lengthwise along each inner top side of the tank. One advantage of this method is that if the tank water is low, the cold spray hits the upper part of the cans. In a third method, air is forced through perforated pipes on the bottom of the tank and, in rising, the air agitates the water.

If mechanical power is not available, the tank water may be agitated by allowing the cooling water to flow through the tank. As a last resort, the tank water may be stirred by hand.

Spray-type wet storage is usually in the form of a cabinet with a side opening. The water is cooled by mechanical refrigeration either above (fig. 7) or below (fig. 8) the cans and then is sprayed over the shoulders of the cans. The cold water cools the milk by flowing down

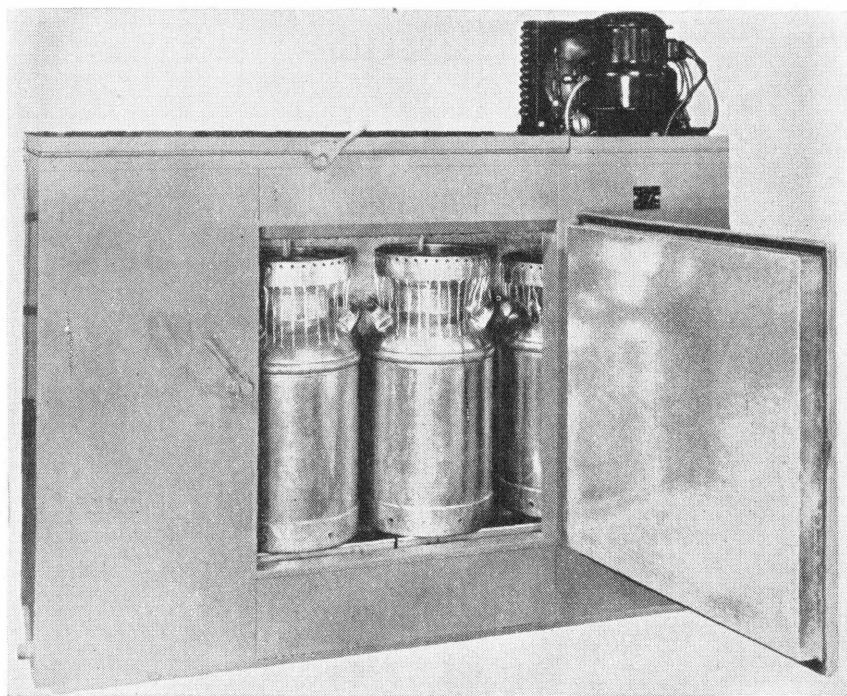


FIGURE 7.—A spray-type wet-storage cabinet in which the water is refrigerated in the top and flows down over the cans.

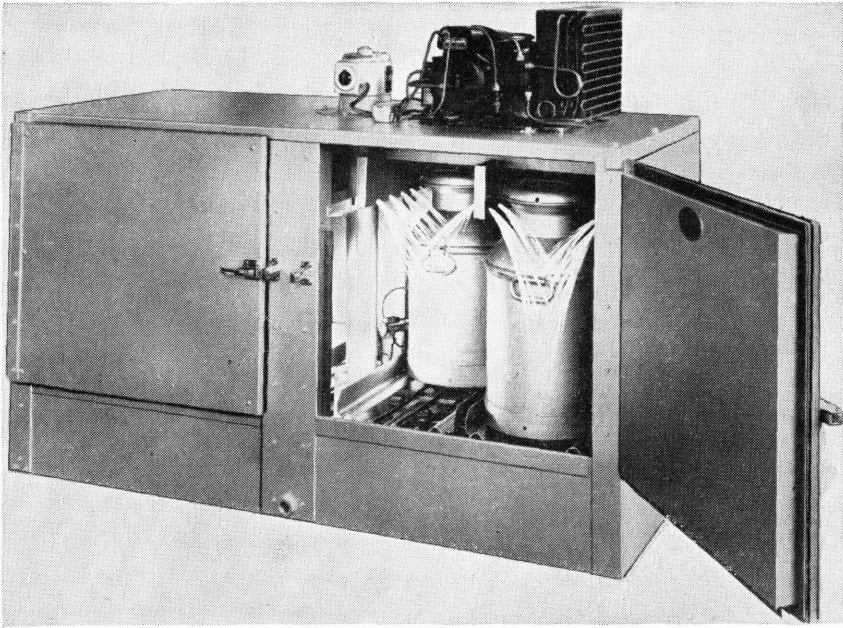


FIGURE 8.—A spray-type wet-storage cabinet in which the refrigerating coils are in the bottom of the cabinet. Cold water pumped from the bottom is sprayed over the shoulders of the cans.

over the outside of the cans. The water is recirculated by a pump. These cabinets are quite effective, and the side opening saves considerable labor of lifting cans. Some of these cabinets can be converted into small bulk-storage units.

Dry Storage

Dry storage in general is less efficient than either wet storage or bulk storage because air is used for the transfer of heat, and air is a much poorer conductor of heat than either water or metal.

On farms where a large volume of milk is produced it often is more economical to use a large walk-in dry-storage box, where cans may be stacked one on top of another, than to build or buy enough wet-storage tanks to hold the same number of cans. The walk-in box is in effect a heavily insulated room with a full-size insulated door (fig. 9). It can be constructed in any size necessary to take care of the volume of milk produced. Where the volume of milk is small, cabinet-type dry-storage boxes may be used. The main advantage of the walk-in box is that it requires much less space than wet-storage tanks for the same volume of milk.

Dry-storage boxes are now almost always cooled by mechanical refrigeration. Cooling may be accomplished by direct expansion of the refrigerant in coils in the box or by coils circulating cold brine which in turn has been cooled in a tank by direct expansion coils. Often this brine is used also in the surface cooler.

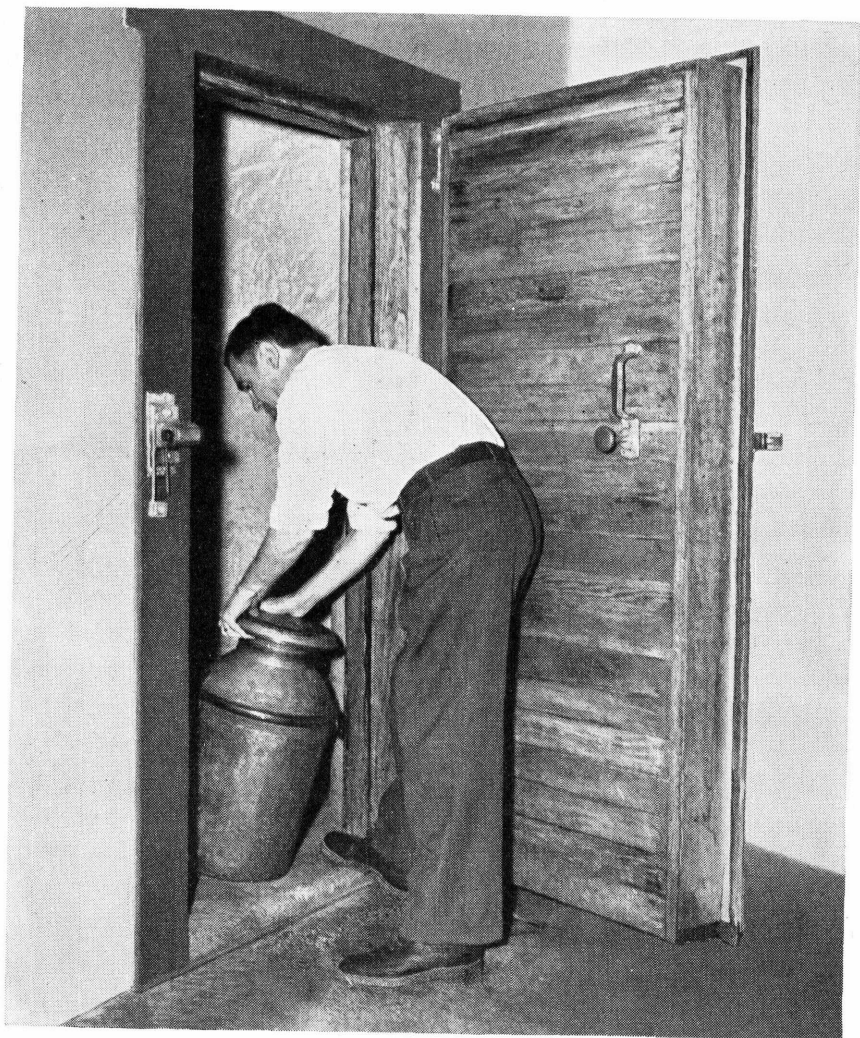


FIGURE 9.—A walk-in dry-storage box.

Walk-in boxes are built into the milkroom. Therefore, proper construction, especially insulation, is essential. The walk-in box should be constructed under competent supervision according to plans which have been prepared by a qualified engineer.

Another form of dry storage, which may be used in the colder sections of the country, is known as the ice well. The ice-well "refrigerator" consists primarily of a pit in the ground in which a solid cake of ice is formed during the winter. The usual method of forming a solid cake of ice is by sprinkling or throwing from 5 to 15 gallons of water at a time into the pit a number of times daily in freezing weather. After the ice cake is frozen, the pit is closed. It is used during the summer months as a refrigerator or ice box for dairy and other food products. For additional information on building an ice

well, see United States Department of Agriculture Circular 155, *The Ice Well for the Dairy Farm*.

Bulk Storage

Farm cooling and storage of milk in bulk, in a refrigerated tank, was begun in California about 1938 and since then has spread throughout the rest of the country. The fresh warm milk is strained directly into the refrigerated tank through a strainer which fits into the tank cover (fig. 10) or, if a combine milker is used, the milk flows into the tank through a pipeline strainer. The tank is cooled by mechanical refrigeration, the type of refrigerant and the method of application varying with the make of tank. The tank usually is equipped with a motor-driven agitator, a thermometer, and a metal measuring rod marked in sixteenths or thirty-seconds of an inch. At present, stainless steel is the most popular lining material and many tanks are also covered with stainless steel.

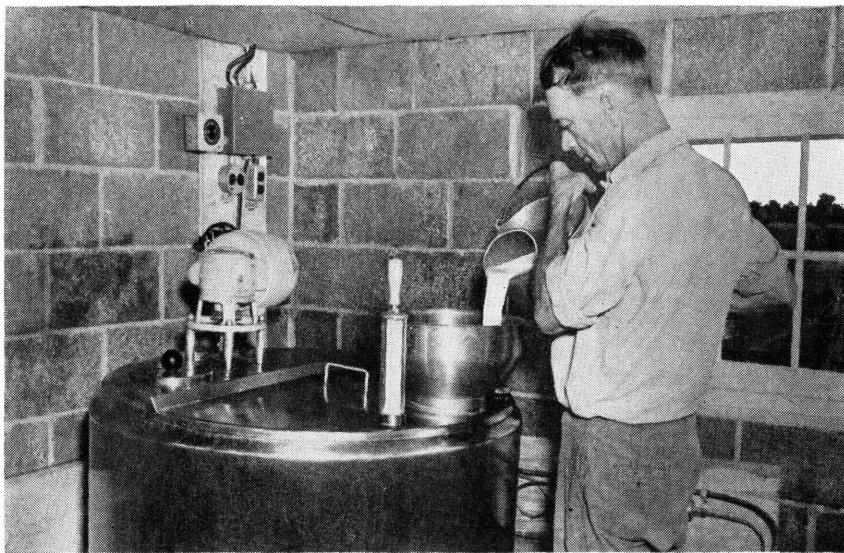


FIGURE 10.—Straining milk into a small bulk-holding tank.

Bulk-holding tanks must be installed carefully. They must be leveled and anchored firmly to the floor so that, once calibrated, they cannot be moved. As soon as the tank is properly installed, the milk-control authority, or someone designated by him, calibrates the tank. To do this, he fills the tank with water by pouring 5 gallons at a time into the tank from an officially standardized 5-gallon can (fig. 11). After he adds each 5 gallons and the water has ceased moving, he records the depth of the water on the measuring rod. When the tank is full, he makes a chart showing the quantity of liquid that will be in the tank at each mark on the calibrated rod. He numbers each tank, rod, and chart so that neither the rod nor the chart will be used with another tank. Each time the milk is collected, the depth of the milk in the tank

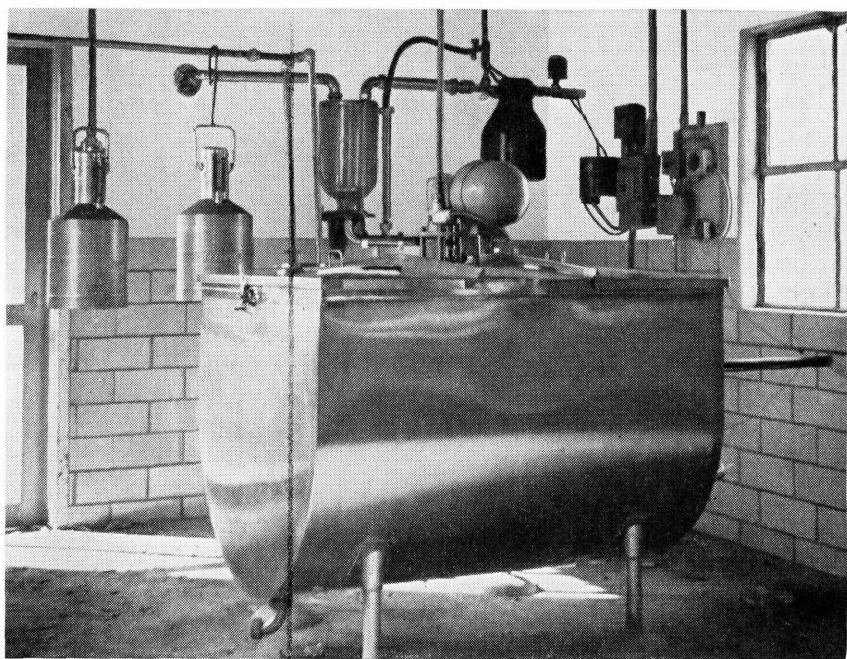


FIGURE 11.—A 200-gallon stainless-steel bulk-holding tank. The outlet pipe connection is at the left on the bottom of the tank and directly above it is the outlet-valve handle. On top of the center of the tank is the agitator motor. Hanging at the left rear are the two official 5-gallon cans used for calibrating the tank. The refrigerant enters the tank through the pipe at the right, under the window, which connects with the compressor outdoors. The glass jar in the rear is the releaser jar for the combine milker.

is measured with the rod and the chart is used to determine how much milk is in the tank.

It is claimed that, with normal milking rates, these tanks will cool all the milk to 38° F. within about 15 minutes after milking has been completed, that they will hold the milk overnight with a change in temperature of only 1 or 2 degrees, and that when morning milk is added the temperature will not rise above 45° and will again be cooled to 38° within 15 minutes.

If the milk is collected in tank trucks, the milk in the farm tank is first measured (fig. 12), then it is stirred thoroughly and a sample is taken for fat determination (fig. 13). The milk then is pumped into the tank truck (fig. 14) and hauled to the milk plant. If tank-truck pickup is not available, the farm tank can be set up on legs high enough to permit the milk to be drawn off into cans.

Reported advantages to the farmer of the tank-truck pickup system include: (1) Losses of milk due to can stickage and accidental spillage between farm and plant are eliminated, (2) use of milk cans is eliminated, (3) hauling cost is reduced, (4) milk is measured, sampled, and sold under the farmer's observation in his own milkroom, (5) the milk sample for fat determination is taken under improved conditions and the farmer can take a duplicate sample if he wishes, (6) better



FIGURE 12.—Measuring the milk in a farm bulk-holding tank by reading the depth on the calibrated stainless steel rod.

quality milk results from faster cooling and storage at a lower temperature, and (7) less milkroom space is required.

Some of the factors that tend to limit expansion of the use of the bulk-milk-handling system are the initial high cost of equipment for the farmer, lack of enough farmers using the bulk-holding tanks to make the establishment of a tank-truck pickup route economical, and inadequate farm driveways.

THE COOLING OF CREAM

In general, the rules for cooling milk apply with equally good results to cooling cream.

Cream should be cooled immediately after it is separated. If the quantity is relatively large, it is best to precool it over a surface cooler before placing it in cold storage. If the quantity is small, it may be put into small cans and placed in cold storage without being precooled, but it should be stirred at regular intervals with a metal stirrer that has been properly cleaned and treated to kill bacteria, until the temperature of the cream has been lowered to 50° F. or below.

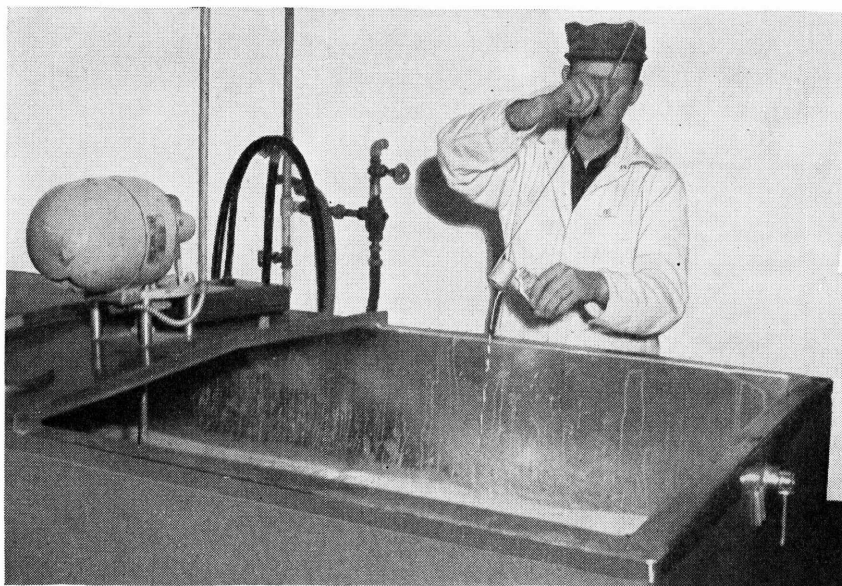


FIGURE 13.—Sampling the milk in a farm bulk-holding tank.

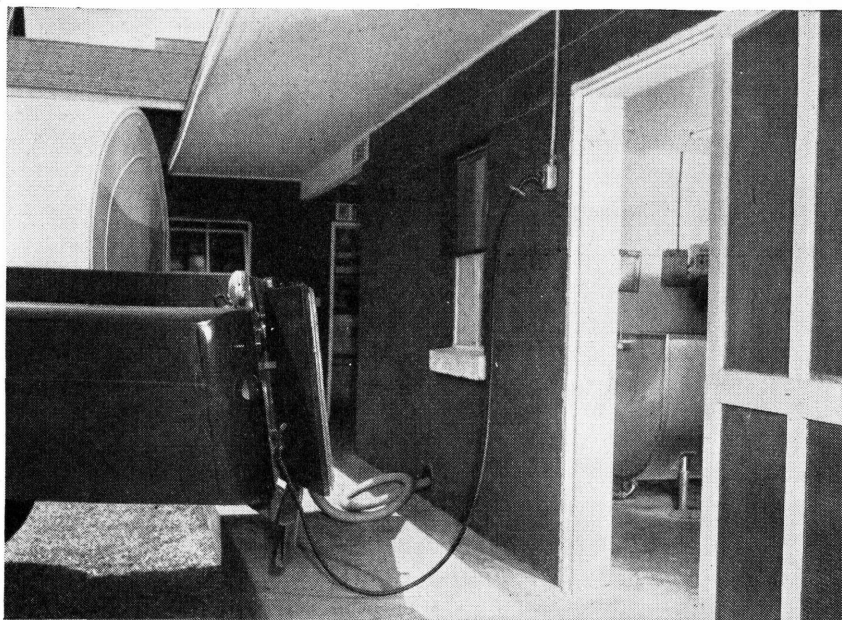
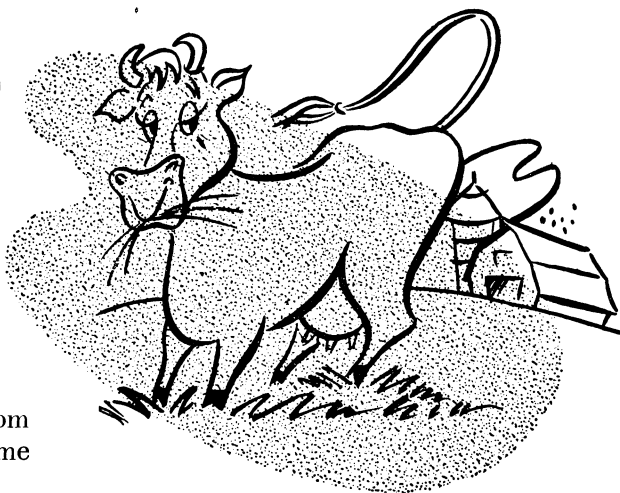


FIGURE 14.—Pumping the milk from a farm bulk-holding tank into a tank truck.

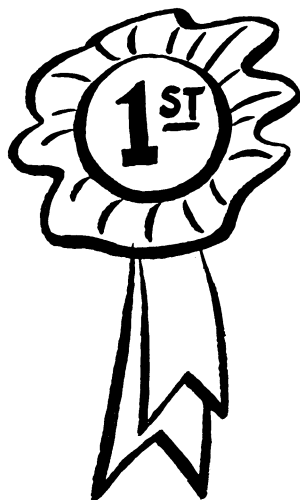
Fresh cream should be cooled thoroughly before it is mixed with cold cream. Cream cools relatively slowly, and it is therefore even more important to use ice or refrigeration in cooling cream than in cooling milk.

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